ESTIMATING A STATE OF AT LEAST ONE TARGET USING A PLURALITY OF SENSORS

BACKGROUND TO THE INVENTION

[0001] The present invention relates to estimating a state of at least one target using a plurality of sensors.

[0002] The deployment of sensor networks to monitor and track events, objects and situations in a variety of environments is becoming widespread. Uncertainty due to random noise is endemic in sensor measurements, but it is known to attempt to reduce its effect using filtering processes. Sensors can generate faulty measurements for a number of reasons, such as power failure, physical damage, and mis-calibration. If parameterised models for the fault types are available, they can be exploited by a fault recognition algorithm; however, often an explicit fault model is not known, in which case the algorithm must be able to deal with model incompleteness.

[0003] It is possible to decentralise the filtering processes in order to try to reduce the computational and communication bottlenecks; however, this can exacerbate the problem of a faulty sensor because its measurement may be fused at multiple sites and then the fused data is re-propagated to further fusion nodes so the impact of a fault can spread through the network. This means that there is a particularly strong imperative to deal with faulty sensor data in a networked sensor fusion system.

SUMMARY OF THE INVENTION

[0004] Embodiments of the present invention are intended to filter and fuse uncertain sensor data to try to ensure that it produces statistically consistent state estimates.

[0005] According to a first aspect of the present invention there is provided a method of estimating a state of at least one target using a plurality of sensors, the method including:

[0006] (1) receiving a plurality of target observations from a respective plurality of sensors;

[0007] (2) using the target observations to compute target state estimates;

[0008] (3) assessing whether each of the target state estimates suffers from one of a set of modelled possible fault types;

[0009] (4) adjusting the target state estimates to compensate for a said modelled fault type if that target state estimate is assessed to suffer from that modelled fault type;

[0010] (5) computing a reliability value for each of the target state estimates;

[0011] (6) fusing the target state estimates based on the computed reliability values to produce a fused target state estimate.

[0012] The steps (1), (2) and/or (3) can involve a multi-hypothesis dual Kalman filter process. The method may further include estimating a time period during which each of the target state estimates suffered from the at least one modelled possible fault type.

[0013] The method may include calculating a failure hypothesis associated with each of the target state estimates, the failure hypothesis includes a state covariance matrix; predictions for the target state estimate that exclude at least some of the observations; a probability value associated with the target state estimate suffering from the at least one modelled fault type.

[0014] The step of computing a reliability value for each of the target state estimates may be performed for the observation received from each sensor individually. The step of computing the reliability of the target state estimates can include computing a distance between the target state estimate as computed using the observation from a first one of the sensors and a target state estimate as computed using the observation (s) from at least one other of the sensors. A said target state estimate can be computed as being unreliable if the distance exceeds a predefined threshold value. The step of fusing the target state estimates can include fusing the target state estimates only if the target state estimates are computed as being reliable. The fusion step can include Kalman filter (or even covariance intersection) and mixture reduction processes.

[0015] According to another aspect of the present invention there is provided a computer program product comprising a computer readable medium, having thereon computer program code means, when the program code is loaded, to make the computer execute method of a estimating a state of at least one target using a plurality of sensors substantially as described herein.

[0016] According to yet another aspect of the present invention there is provided a system configured to estimate a state of at least one target using a plurality of sensors, the system including:

[0017] a plurality of sensors configured to receive target observations;

[0018] a device configured to receive a plurality of target observations from the plurality of sensors;

[0019] a device configured to use the target observations to compute target state estimates;

[0020] a device configured to assess whether each of the target state estimates suffers from one of a set of modelled possible fault types;

[0021] a device configured to adjust the target state estimates to compensate for a said modelled fault type if that target state estimate is assessed to suffer from that modelled fault type;

[0022] a device configured to compute a reliability value for each of the target state estimates;

[0023] a device configured to fuse the target state estimates based on the computed reliability values to produce a fused target state estimate.

[0024] The sensors may be configured to transfer their observations to a remote device that includes: the device configured to use the target observations to compute target state estimates; the device configured to assess whether each of the target state estimates suffers from at least one modelled possible fault type, and the device configured to adjust the target state estimates to compensate for a said modelled fault type if that target state estimate is assessed to suffer from that modelled fault type.

[0025] Each of the sensors may include the device configured to use the target observations to compute target state estimates; the device configured to assess whether each of the target state estimates suffers from at least one modelled possible fault type, and the device configured to adjust the target state estimates to compensate for a said modelled fault type if that target state estimate is assessed to suffer from that modelled fault type.

[0026] Embodiments of the system described herein typically incorporate two data processing stages. The first stage attempts fault recognition and removal by hypothesising a number of models to describe the faults. This enables the fault to be removed from the data. For each model a recursive estimator can be applied to the data and a Bayesian approach